A MINERALOGICAL INVESTIGATION OF SOME GOLD COAST SOILS [1])

R. HAMILTON
Accra, Gold Coast

All soils go through a series of changes. Initially they consist of freshly accumulated fine and coarse grained rock material and minerals. Thereafter comes a stage, when they consist chiefly of more or less rounded hard and very resistant minerals. Finally, the soil contains only some alteration and decomposition products. A mineralogical investigation of soils, therefore, can tell us a lot e.g. about:

its *age* (weathering stage),
its *classification, correlation* or *mapping,*
its *fertility,*
its *origin* (see parent rock and weathering ways),
its *transport.*

However, detrital soil minerals are often difficult to identify because they are usually masked by adhering alteration products.

These obscuring coatings or films must be clarified first. Several methods exist for this procedure. In accordance with the here in Aburi available chemicals, glassware and heating (only metaldehyde solid fuel blocks) it has been done simply by soaking with 7% (2N) HCl (1 : 5) during three days without heating. Approximately 25 grams of soil were soaked in 100 ml of diluted HCl. After three days, the soil is washed with much rain water and all dirt is then removed, except the minerals. These are concentrated, dried in the sun and sieved through a 100 mesh (0.15 mm) metal gauze. Thereafter they are mounted with Canada Balsam on a glass slide.

The coarse fractions were only studied with a hand lens or binocular microscope. Usually they consisted only of rock fragments, concretions, quartz and opaque minerals, but sometimes they contained also pyroboles (= pyroxenes + amphiboles), garnet, epidote, rutile and mica flakes. The mounted fine grained fraction, on the other hand, was counted under a polarising microscope.

Counting is necessary to get an approximate idea of the mineralogical composition; moreover, it avoids an over-estimation of coloured and opaque minerals. Each time one hundred successive grains along an arbitrary straight line through the slide were counted.

No separation of a heavy fraction was possible because there was no bromoform.

For this investigation were selected six groups of dark coloured soils from the dry savannah plains, East of Accra. Group 1 to 5 represent the melanites or alkaline, black heavy clays derived from a basic hornblende gneiss (garnetiferous) and group 6 are the alluvial fluviomarine soils (alluvites).

Furthermore, two different groups of bright coloured soils (rubrites) from the forested hills in Ashanti were investigated. Group I include the drifted

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mantle soils which cover in situ soils, and group II are purely residual soils. These residual soils are derived from schists (Bekwai series), from mica granites (Kumasi series) or from mica gneisses (Swedru series).

Summing up, the groups are:

Group 1: Three profiles giving the approximate mineral composition of the parent material of the black clays. These all were shallow stony, hill soils (except the Bumbi) with an acid pH of 6–6,6 and light texture.

Group 2: One buried profile which is not considered further.

Group 3: Four pits from the centre of the black clay area with dark coloured heavy clays and an alkaline pH of 7,8–8,2.

Group 4: Three pits near the boundary of this area, also with dark-coloured heavy clays but a varying pH of 6,6–7,6.

Group 5: Four pits outside the area for comparison. These are black *acidic* clays with a pH of 6–6,8.

Group 6: Six pits near the Volta mouth, being alluvial soils of strongly varying textures and pH.

Group I: Five profiles of a very acid but less heavy, red loam, pH 5–5,8.

Group II: Six profiles of a less acid but very heavy red loam, pH 5,4–6,8.

PIT MAP A Scale : 1/500.000

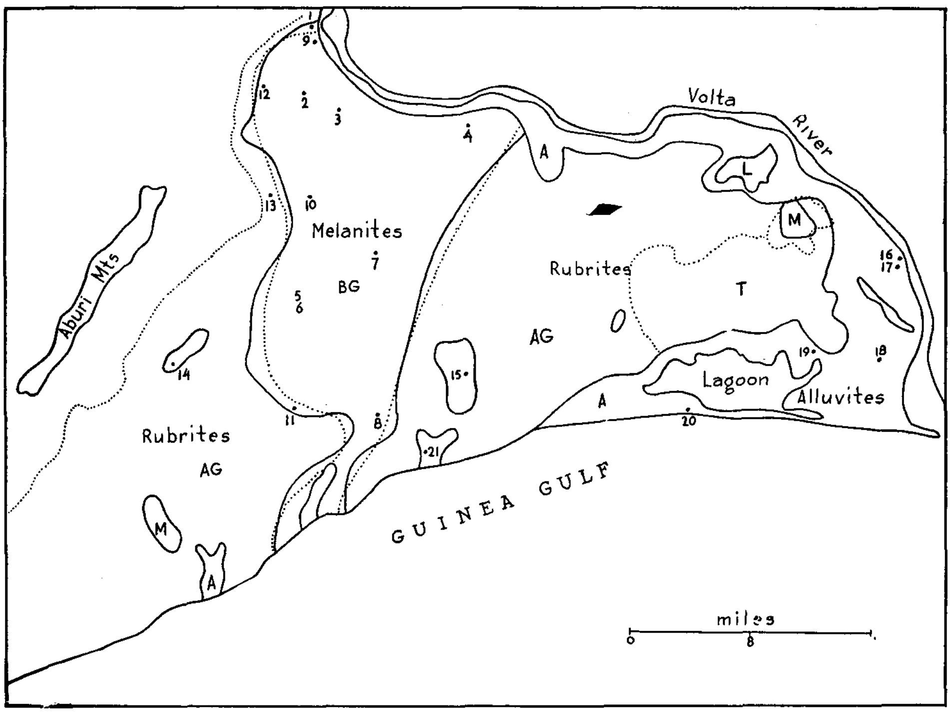

FIG. 1.

Boundary of the Rocks (AG-acidic gneiss, BG-basic gneiss, T-tertiary deposits).

Boundary of the Soils (A-alluvites, 7 series over Quaternary deposits, M-melanites, 9 series over basic gneiss, R-rubrites, 18 series over acidic gneiss).

L Lagoon (L).

•21 Pits.

A general remark may precede. From the tables A and B and the accompanying pit maps, it appears that the mineralogical variation in these profiles is but small notwithstanding the difference in colour, pH or texture of the used layers. This is not strange because these properties are independent of these relatively coarse grained minerals. On the contrary, these properties are dependent on the ultramicroscopic part of the soil.

In the field the melanites generally show residual profiles with gradual transition from parent rock to soil. But sometimes also transported profiles with stonelines are met with. Therefore a rather elaborate mineralogical analysis was necessary to solve this problem.

The results of these countings are as follows: the composition of the more important parent materials of the black clays (from group 1) appears to be: rutiliferous epidote amphibolite, garnetiferous pyroxenite and *garnetiferous hornblende gneiss.* They are characterized by almost equal parts of quartz, pyroboles and garnet. Moreover, the Bumbi has much epidote and rutile. Apart from the many pyroboles, the presence of a little plagioclase and the angular minerals prove that all these soils are young or juvenile and almost not transported.

The soils of the centre of the black clay area (group 3) show clearly their origin from the garnetiferous hornblende gneiss. They are chiefly made up of quartz and garnet. Still, there is a little hornblende and sometimes a trace of plagioclase left, proving that these soils are not weathered out, but virile. The fact that the heavy garnet is concentrated more than the lighter quartz indicates that these soils are not perfectly in situ, but have had a small amount of "centrifugal transportation and sortation". Transport is also inferred from the sometimes sub-rounded grains. Only partially the isolated peaks can be centres of origin; for the numbers 7 and 8 (see Table 1) this probably is not the case.

Near the boundary of the same area we see (in group 4) a great decrease of garnet but a strong increase of quartz; this is wholly in accordance with the just mentioned "centrifugal transportation" of material. The vicinity of a hornblende rock, however, is still perceptible from the few hornblende grains counted. These soils are virile to senile and likewise little transported.

As to the soils outside of this area (group 5), quartz has increased enormously and it is indisputable strongly predominating. All the other minerals are present only in very small quantities. These soils are certainly senile. Significant is also that the minerals of these soils are more rounded than those in the groups earlier mentioned. This was especially clear in the coarse grained fractions, indicating some more transport.

Finally, we come to the minerals of the alluvial soils (group 6) which are included only for comparative purposes. It cannot be surprising that they consist chiefly of quartz. For the rest they contain many other minerals, but these only in small quantities. Moreover, the minerals are rather rounded, especially the coarser ones. Such a varying mineralogical composition, rich in quartz, is not unusual in alluvial soils where normally many properties vary considerably. Likewise much transportation and sortation is a common occurrence in alluvites. Sample no 21 is rich in garnet because it is near to the garnetiferous hornblende gneiss of its hinterland. The abundance of opaque minerals in 19, however, is rather remarkable.

Table 1. Minerals of the Accra Plain soils.

Pit no. (see Fig. 1)	Soil series	Colour and Texture	Depth in inches	pH	Quartz	Plagioclase	Augite	Epidote	Garnet	Hornblende	Kyanite (Disthene)	Pyroboles (fibrous)	Rutile	Staurolite	Tourmaline	Zircon	Opaque	Sundries
	Group 1 (Parent materials of the melanites)																	
1	Bumbi	dBc	6-14	6.0	18		1	25	12	34			8				3	
	,,	dBc	14-18	6.2	15		+	19	10	39			10			1	5	
2	Kloyo	dBl	1-8	6.0	33	1		2	27	25			5			1	6	
	,,	dBl	>8	6.0	37	1		1	29	23			3			2	4	
3	Osudoku	dBc	0-7	6.6	25	1	1	3	15	32		13	3			1	6	
	,,	dGc	>7	7.0	21	1	2	5	17	34		14	1			+	5	
	Group 2 (Buried soil)																	
4	Jongwa	dBc	5-15	6.4	27	1			45	11		+	2			+	14	
	,,	Bs	60-70	7.2	22	1			50	9		+	+			1	17	1 Hy
	,,	dBc	101-119	7.8	25	+			51	9		1	1			+	13	
	Group 3 (Central melanites)																	
5	Tachem	Bc	41-58	7.8	22	?			69	3			3			+	3	
	,,	dBc	58-69	7.9	25				63	2			5			2	3	
6	Akuse	dBc	41-54	8.0	35	+		4	47	3			6			1	4	
	,,	pBc	54-66	8.2	31			3	52	2			5			2	5	
7	Prampram	dBc	15-26	7.8	21			1	70	1			3		+	1	3	
	,,	pBc	26-38	8.0	26	?		+	64	2			5			+	3	
8	Akuse	Gc	0-24	7.8	37			+	53	1			3			+	6	

Group 4 (Marginal melanites)																		
9	Akuse (brown)	YBc	39-57	7.6	81			3	5	2			2			2	5	
	”	YBc	57-65	7.8	83			2	4	1			3		+	2	5	1 Si
10	Jaw Wulu	Gc	26-38	6.6	77			7	3	+			5			2	6	
	”	Gc	38-54	7.0	79			6	2	1			6			1	5	
11	Akuse (over	dGc	10-35	6.6	80			4	5	2			3			1	5	
	Krabo)	Bs	88-114	7.0	81			7	3	1			2			2	4	
Group 5 (Outside melanites)																		
12	Osibi	Bc	25-39	6.0	86			3	3				2			1	5	
	”	Gc	39-48	6.0	85			2	2				5			2	4	
13	Tachem	dBc	9-30	6.2	89			3	1				2			+	5	
14	Jaw Wulu	Gc	8-16	6.0	92			3	1	+						1	3	
15	Akuse	Gc	10-29	6.8	89			+	5				+			2	4	1 Sp
Group 6 (Alluvites)																		
16	Kakum (between	Bc	20-39	6.0	91			+	+	5			+			1	3	
	Chichiwere)	pBs	39-48	6.5	87			3	3	2			+	+	+		5	1 Hy
17	Densu	Bc	16-32	5.0	85			2	2	+							11	
18	Ayensu	Gc	10-22	6.0	90			2					1			2	5	
19	Oyibi	dGc	8-19	7.0	73			3	2	+					+	2	20	
20	Keta	dBs	5-18	7.0	91			+					1	+	+	1	7	?
21	Muni	Bc	6-18	8.0	71			4	18				+	+		2	5	
														+				

As to the clay minerals from the fraction $< 2\,\mu$, it was already expected from the black clay properties that these must be chiefly montmorillonitic. Indeed, an X-ray (Cu K_α) diagram made from a heavy black Akuse clay (after treatment with 10% hydrogen peroxide and diluted (0,2 N) hydrochloric acid) shows mainly the typical montmorillonite lines, besides traces of kaolin and quartz. Most probably also a trace of calcite can be expected.

This is completely in accordance with the results of Dr. I. Stephen in 1952, who likewise found the same minerals in such soils.

PIT MAP B Scale : 1/500.000

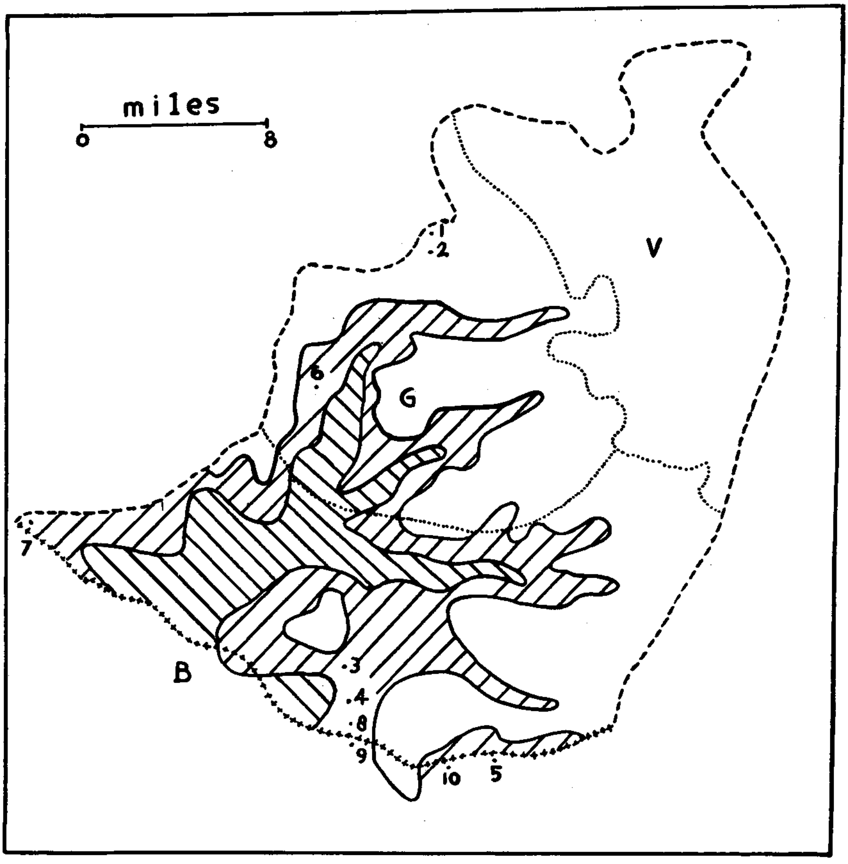

Fig. 2.

----- Boundary of the River Basin.

.... Boundary of the Rocks (V-sandstones, G-granites, B-phillytes and schists).

——— Boundary of the Soils (3 kinds).

. . . . . Road.

Mantle soils (16 series), upland positions. }
Mixed soils (transition zone). } Rubrites.
Residual soils (12 series), lowland positions. }

·10 Pits.

In the Ashanti soils, which were collected in the Upper Tano Basin the following results were obtained.

Table 2. Minerals of the Tano Basin soils.

Pit no. (see Fig. 2)	Soil series	Colour and Texture	Depth in inches	pH	Quartz	Plagioclase	Augite	Epidote	Garnet	Hornblende	Kyanite (Disthene)	Pyroboles (fibrous)	Rutile	Staurolite	Tourmaline	Zircon	Opaque	Sundries
	Group I (Drifted mantle soils)																	
1	Chira over Kumasi	Ol	24-45 (dr.)	v.a.	77			1			2				+	2	18	
	,,	Ol	45-73 (r.)	v.a.	68			1					+			+	31	?
2	Chira over Kumasi	Oc	24-39 (dr.)	5.0	71			+			1				1	+	27	
	,,	Rc	39-44 (r.)	v.a.	54				+		+					1	45	
3	Chira over Bekwai	Rl	14-24 (dr.)	5.4	76			+			3			+	+		21	
	,,	Rl	43-57 (dr.)	5.6	76			+			5		+	?			19	
	,,	Rl	57-79 (r.)	5.6	68			1			6		+				25	
4	Akumadan	dRl	29-73 (dr.)	5.8	80			?			1						19	
	,,	pRc	113-132 (dr.)	v.a.	77			+									23	
5	Chira	Oc	15-25 (dr.)	6.4	84				+								16	
	,,	Ol	72-84 (r.)	5.5	79			?								?	21	
	Group II (Residual soils)																	
6	Kumasi	Rl	60-77	6.2	53			1		+	?					+	46	
7	Bekwai	Rc	45-66	6.8	75			1						+	+		24	
8	Bekwai	Rl	16-25	6.0	55			+			?						45	
	,,	Rl	51-72	5.4	51								+				49	
9	Bekwai	pRBl	102-129	5.2	78			+							+		22	
10	Bekwai	Rl	36-62	5.4	83			?									17	
11	Swedru	Ol	56-72	6.5	90					1					1	?	8	

The chief problem of these Tano soils was, how to distinguish the drifted mantle soils from the residual soils. Generally, the differences are clear but the field surveyor is not always so fortunate. Especially in the transition zone with mixed soils there are many problems. Most samples, therefore, come from this area. With a trained eye and the touch some difficulties can be solved, but still there are several cases which escape from a satisfactory explanation. In such a case a microscopical investigation may help.

The general mineralogical impression of all these soils is that they are senile lateritic soils. This means that there are only a few weatherable minerals left. Practically no pyroboles or plagioclases are seen and the bulk of the minerals consist of resistant ones like quartz and opaque ores (magnetite, ilmenite etc.). Especially the pits 6, 8, and 11 are very rich in these hard components. Further they differ from the melanites – apart from their colour, texture and pH – in a greater frequency of metamorphic minerals like kyanite, staurolite and tourmaline, which occur in the rocks of this area.

When we compare the drifted layers with the residual ones (in group I), it is noticeable that the drifted horizons contain more light quartz and less opaque ores. On the other hand, the residual horizons have less quartz but more heavy ores. This is quite understandable, as every transportation causes a sortation at the same time. In other words, the heavy minerals are left behind and the lighter ones are taken along. In this way the light quartz is more concentrated in the moving layers and the heavy minerals are more left in the stable part of the soil. But still more significant for the drifted layers are the several, perfectly rounded quartz grains resembling small colourless shot–especially found in the coarse fractions. In the same fraction of the residual layers – and in all the other residual soils (of group II) as well – only subangular quartz was seen ! Apart from the general remarks that have been made, this group II does not show any other particulars which need further description.

For comparative purposes a sample from the *Ayensu Basin* has been added. It is a Swedru series which, externally, strongly resembles the Kumasi series. Visually they are difficult to separate and apparently mineralogically as well. From one Kumasi soil an X-ray photograph was made in the same way ; it consists chiefly of kaolin with only a trace of quartz – again a normal composition of senile, lateritic clays.